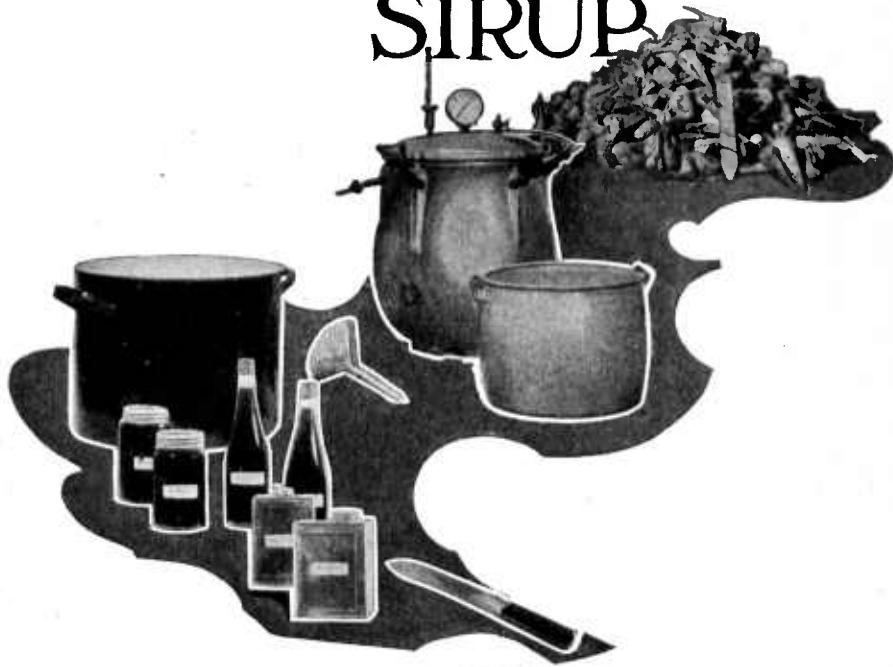


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FARMERS' BULLETIN 1241
UNITED STATES DEPARTMENT OF AGRICULTURE

AN IMPROVED METHOD *of* MAKING SUGAR-BEET SIRUP



THIS BULLETIN tells how to grow sugar beets in the garden and describes a simple process of making from them a palatable and nutritious table sirup with a pleasant flavor. A patent for the process of making the sirup has been issued for the benefit of the public, so that anyone is free to use it. Tests have proved the process to be practicable.

Sugar beets may be grown in any locality which has tillable soil that is capable of producing good crops of vegetables. A small piece of ground is sufficient for planting a few rows of beets—enough to furnish the family with sirup. The tools needed are necessary in any garden operation—a spade, a hoe, and a rake.

All mature sugar beets, if properly handled, will produce a sirup. The beets are cleaned, peeled, cut into thin slices, and soaked in hot water to extract the sugar. The liquid is then treated and boiled down to the thickness desired. Detailed directions are given in the following pages.

Contribution from the Bureau of Plant Industry

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Washington, D. C.

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AN IMPROVED METHOD OF MAKING SUGAR-BEET SIRUP.¹

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GROWING SUGAR BEETS FOR SIRUP.

THE PRODUCTION OF BEET SIRUP involves two distinct operations, (1) the growing of the beets and (2) the making of the sirup.² The sirup making embraces two essential operations, the extraction of the juice from the roots and the boiling down of this juice to the desired consistency.

THE EQUIPMENT NECESSARY.

Sugar beets may be grown and sirup produced in any locality which has tillable soil capable of producing good crops of vegetables. Therefore, anyone having a small piece of fertile tillable ground and the usual garden implements, a spade, a hoe, and a rake, is equipped to grow the beets necessary for the production of a home supply of sirup. In some localities the beets produced are richer in sugar than they are in other localities, but all mature sugar beets, if properly handled, are capable of producing sirup. The richer the roots are in sugar, the larger the quantity of sirup that may be produced from a given quantity of roots and the less the time that will be required to reduce the juice to the desired consistency.

¹ This bulletin supersedes Farmers' Bulletin 823, entitled "Sugar-Beet Sirup," by C. O. Townsend, Pathologist in Charge of the Office of Sugar-Plant Investigations, Bureau of Plant Industry, and H. C. Gore, Chemist in Charge of the Fruit and Vegetable Utilization Laboratory, Bureau of Chemistry.

² A Government patent for the process of making sirup from sugar beets (patent No. 1155806, Oct. 5, 1915) was issued to the authors of Farmers' Bulletin 823, H. C. Gore and C. O. Townsend, U. S. Department of Agriculture. Another patent (No. 1370372, Mar. 1, 1921), covering the improved process described in this bulletin, has been issued to Sidney F. Sherwood. The use of the processes covered by either of these patents is free to any citizen of the United States.

SELECTING THE LAND.

The ground selected for growing the beets should be well drained and fairly fertile. Extremely poor, shallow, sandy, or hard soil should not be used for beets until it has been put in proper condition for crop production; likewise, ground that has been very heavily manured should be avoided, since such soil sometimes produces very large roots, poor in sugar. A few rows of sugar beets in the garden will generally be sufficient for a supply of sirup for home use. From 100 pounds of roots 5 to 8 pints of sirup can be produced. Beet

roots when mature should weigh from 1 to 2 pounds each, and about 60 good-sized beets will weigh 100 pounds. These facts will enable one to estimate the area that will be needed to produce the home supply of sirup.

If more beets are grown than are necessary for the sirup supply, they will be found excellent for the table. When partly grown the entire plant may be used as greens, and when mature the roots may be cooked and served like garden beets. All sugar beets are white, and when properly grown they are generally much richer in sugar than the garden beet and just as tender. Sugar beets, either raw or cooked, are excellent feed for chickens, hogs, and other live stock.



FIG. 1.—A beet root of good shape.

The ground selected for growing the beets should be plowed or spaded to a good depth, remembering, however, that too much subsoil should not be brought to the surface at one time. The reason for a deep root bed for sugar beets is apparent from the shape and length of the root, as shown in figure 1. The ground should be plowed or spaded in the fall, but good results may be obtained by doing this work in the spring, provided the ground previously has been in good tilth. As early in the spring as conditions will permit, the ground should be harrowed or raked until it is firm, smooth, and free from lumps. The surface soil should not be too fine, especially in those sections where high winds are expected during the early summer. The ground should be kept free from weeds, but should never be

PREPARING THE SEED BED.

The ground selected for growing the beets should be plowed or spaded to a good depth, remembering, however, that too much subsoil should not be brought to the surface at one time. The reason for

worked when too wet. The proper time, always, for working the ground is when it is friable; that is, when it falls apart readily when handled.

PLANTING THE SEED.

Sugar-beet seed usually may be obtained, at least in small quantities, from the large seed dealers. A pound of seed will plant one-tenth of an acre if the work is done carefully. Usually a few ounces of beet seed will produce a quantity of beets sufficient for sirup making and for table use for the average family. The seed should not be planted until the ground is warm and the other conditions right for quick germination and for the subsequent growth of the plants.

Sugar-beet seed should be planted in rows about 20 inches apart and may be dropped either in continuous rows or in hills. If planted in hills each hill should contain from three to six seed balls, and the hills should be about 10 inches apart; if planted in solid rows the plants should be blocked in the manner described below as soon as possible after they are up. The seed should be covered to a depth of one-half inch to 1 inch. The covering should be as shallow as conditions will permit; that is, it should not be so thin that it will dry out and leave the seed without sufficient moisture for germination and it should not be so thick that the young plants can not readily get through to the light.

In growing sugar beets commercially the seed usually is planted with a 4-row drill designed especially for the purpose. In planting small lots of beet seed for sirup making, a garden planter of any of the usual makes, as shown in figure 2, will be found satisfactory. These planters can be set so that they will plant seed either in solid rows or in hills. In case a planter is not available, an area sufficient for sirup production can be planted easily by hand. In this case a shallow furrow may be made with a rake handle or other convenient implement and the seed dropped by hand and covered by using the back of the rake.

CARING FOR THE PLANTS.

If the seed is planted in solid or continuous rows the plants should be blocked. Blocking consists in cutting out a part of the plants with a hoe or other implement, so that the remaining beets stand in tufts about 10 inches apart. In blocking the beets, the direction of the stroke should be at right angles to the row, as shown in figure 3.

As soon as the plants are large enough to be handled conveniently, they should be thinned to one plant in each hill or tuft. This work must be done by hand, since the plants in the hills or tufts stand very close together. The plants should be cultivated and hoed from time

to time, to keep down all weeds and to furnish the best possible conditions for growth.

If the natural water supply is not sufficient, the beets should be irrigated when they show signs of needing moisture. If the beets wilt during the day and fail to recover at night, they should be watered. In case of irrigating, a furrow should be made several inches from the beet row and the water allowed to run down this furrow until the ground is thoroughly wet. In no case should the



FIG. 2.—A garden seed planter.



FIG. 3.—Blocking sugar beets.

surface of the ground around the beets be flooded, since flooding often causes a crust to form around the beet, cutting off the air supply from the root and thereby retarding the growth of the plant. From one to three irrigations will be sufficient in most of the sections where irrigation is necessary.

HARVESTING THE ROOTS.

In most sections of the country from four to six months are required for the beets to reach their proper size and development. The proper stage of development for harvesting will be indicated by a

yellowish tinge of the foliage and by the fact that the beets when pulled leave the ground almost free from dirt, as shown in figure 4. In no case should the beet roots be used for sirup making until they are mature. If the patch of beets is large the roots should be loosened by means of a so-called lifter, of which there are two kinds, the double-pointed and the side lifter. The latter is similar in appearance to a subsoil plow and is operated alongside the beet row, loosening the beets without breaking them. The plants then can be pulled and thrown into piles or rows. If the patch of beets is small and a lifter is not at hand, the beets may be loosened by means of a spade or a spading fork and thrown into piles. The beets should then be topped by cutting them off squarely at the point where the lowest leaf was



FIG. 4.—Field sugar beets, the kind to be grown in the garden for sirup making.

attached. The topping can best be done by means of a heavy knife; usually a single stroke is sufficient to top a beet. The roots can then be made into sirup at once, or they may be stored until a more convenient time.

STORING THE ROOTS.

The roots may be stored either on the surface of the ground or in a pit or a cool cellar and kept for several months. The simplest and least expensive method of storing the roots is to throw them into a pile on the surface of the ground, in a well-drained spot. Dirt should then be thrown over the pile until it is almost or completely covered. If the weather is mild the top of the pile should be covered very lightly or left entirely open for a few days, until the roots have passed the heating stage. As the weather gets colder more dirt should be added, to prevent the roots from freezing and to keep them from wilting.

If the roots are to be pitted a hole or pit is dug in a well-drained place, the size of the hole depending upon the quantity of roots to be stored. The roots should then be placed in the hole and the surface covered with dirt, lightly at first, and the covering increased as the weather gets colder. If the beets are stored in a cellar they should be packed in moist sand or covered with sand or dirt to keep them from wilting.

The two points to be kept in mind in storing beet roots are (1) to keep the roots cool without letting them freeze and (2) to keep them

from wilting. They will work up much better if they are kept fresh and crisp, although the wilting does not materially change their quality.



FIG. 5.—Beet roots for seed. Roots saved for seed should have the leaves removed without injuring the crown.

SUGAR-BEET SEED.

Those who wish to make beet sirup from year to year, especially in the cooler portions of the United States, may grow their own seed if they desire. Just how long seed can be thus produced without serious reduction in the quality of the roots has yet to be determined, but the indications are that at least several generations of beet plants may be produced without reducing the quality of the roots too low for sirup making. Two growing seasons usually are required for the production of sugar-beet seed from seedling plants. It is necessary, therefore, that the beets produced the first season be gathered in the

fall and stored in the manner described above. In case the beets are to be used for seed production they should not be topped, but the leaves should be removed either by twisting them off or by cutting them off with a sharp knife without removing or injuring any part of the crown, as shown in figure 5. In this condition the beets should be stored until spring. They should then be planted in a well-prepared root bed just as early as weather and soil conditions will permit. The early planting of the roots seems to be an important requirement in beet-seed production.

The planting may be done by thrusting a long spade into the earth; the spade should then be pushed forward, the root crowded down back of the spade, as shown in figure 6, and the spade withdrawn. The dirt should then be packed around the root, the crown of which should be flush with or slightly below the surface of the soil, so that the crown is covered with a thin layer of dirt. A light covering over the crown seems to be of advantage in preventing it from drying out, and it also is a protection against late frost. The roots should be well supplied with moisture during the entire growing season, irrigating them if necessary, especially when the seed is forming. When the seed is ripe it may be gathered by pulling it from the seedstalks by hand. The habit of growth of the seed stalk, shown in figure 7, makes the gathering of the seed an easy matter. It should be spread in a suitable place to dry, after which it is ready for the next year's planting. No artificial heat should be used in drying the seed. Each plant produces from a few ounces to a pound of seed; hence, a very few roots will be sufficient to furnish the ordinary family with an abundant supply of seed for home use.



FIG. 6.—Planting beet roots for seed.

MAKING SIRUP FROM SUGAR BEETS.

PREPARING THE ROOTS.

The first step in making beet sirup consists in cleaning the roots and removing the top portion. The roots from which the tops have been removed at the time of harvest, as described on page 7, are soaked in water for a few minutes, in order to loosen the dirt, and are scrubbed thoroughly, preferably with a brush having stiff bristles, in a tub of clean water or under a stream of clean water. Cool

water should be used for soaking and washing, as it restores the crispness of the roots that may possibly have become slightly wilted; roots that have been stored for some time and have become wilted to the point of softness should not be used for making sirup.

The crown or top portion of the cleaned beets should be cut off squarely at the line between the green and white portions. If this

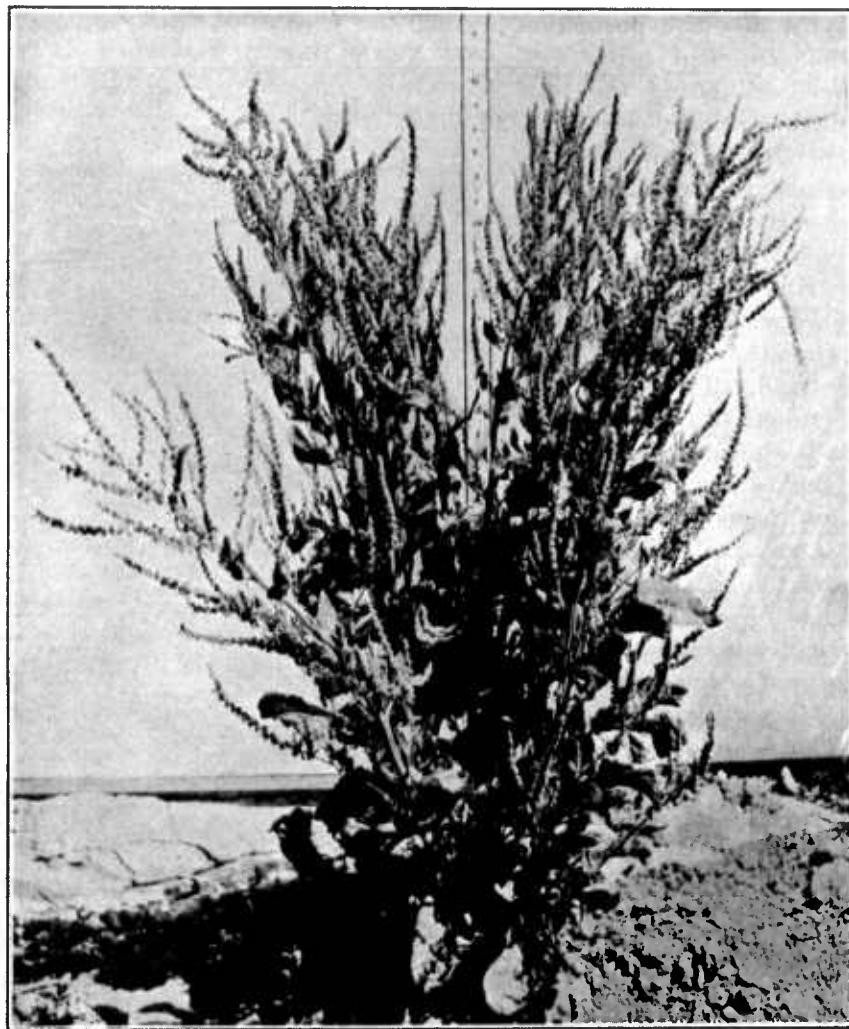


FIG. 7.—A common type of beet seed stalks.

line extends to a considerable point below the lowest leaf scars, the cut may be made at the line of the lowest leaf scars and the green portions then removed by trimming. The reason for this further topping is that the crown contains the greater part of the salts taken from the soil in the process of growth, and it is desirable to have the sirup as free as possible from these mineral salts, because if

present in too large quantities they may impart an unpleasant taste. Coloring matter and other materials in the green portions cause a darker colored sirup and tend to impart an unpleasant taste and flavor. This is true also of the skin or peel, which should be removed. The most satisfactory way to remove the peel is to slice it off with a large-bladed knife.

EXTRACTING THE JUICE.

To extract the juice containing the sugar, the peeled beets are sliced and the slices permitted to fall directly into hot water of sufficient depth to cover them and prevent access of air. Exposure of the peeled or sliced beets to the air results in the rapid darkening of the surfaces, which, if permitted to take place to any extent, causes a dark color in the sirup and tends to impart an unpleasant flavor. The slices should not be thicker than one-sixteenth of an inch and preferably much thinner, because the thinner the slices the more rapidly and thoroughly the juice will be extracted. A large-bladed butcher knife will be found satisfactory for slicing where a comparatively small quantity of beets is to be handled. An ordinary kraut cutter (fig. 8) or some type of vegetable-slicing machine (fig. 9) is more suitable for handling large quantities.

The slices should be permitted to soak for about an hour at a temperature of 174° to 180° F. (78° to 82° C.). An excess of water should be avoided, because it increases the amount of evaporation—and consequently time, labor, and heat—required to reduce the extract to sirup. The proper quantity of water is just sufficient to cover the slices and keep the air from them during the time of extraction, and hot water may be added from time to time as the quantity of slices in the container increases. The top slices may be held under the surface of the water by means of a plate or small wooden rack. A 10-gallon container will hold the slices from 100 pounds of original (untopped and unpeeled) beets and afford room for stirring them occasionally during the extraction.

The extracting should be done in clean vessels made of tin, enamel ware, aluminum, or crockery, or in a wooden container, such as a barrel. If a barrel or other wooden container is used, special care



FIG. 8.—Barrel with upper head removed and kraut cutter securely fixed in place.

must be taken to have it perfectly clean. If a barrel is used it will be advantageous to have a faucet at the bottom to draw off the liquid. Copper or iron vessels should not be used either for the extracting or for the subsequent evaporating to sirup, as copper may give an unpleasant taste and iron a very dark color to the sirup. In case a barrel is used for the extracting, the water should be placed in it at a temperature of just about boiling. The addition of the slices will reduce the temperature sufficiently close to 174° to 180° F., and if the top of the barrel is then covered with heavy cloth the temperature will remain high enough during the hour's standing to



FIG. 9.—One type of vegetable slicing machine.

afford a good extraction. Other containers may cool at a somewhat greater rate, and it may be found advisable to maintain the proper temperature by applying heat; in this case, a thin wooden rack should be placed upon the bottom of the vessel, to avoid scorching the bottom slices. After an hour the liquid is drained off and strained through cheesecloth or muslin. It is not necessary to press the residual slices. This refuse is a good feeding material for chickens, hogs, and cattle. The extract should be of a pale yellow color and slightly opaque. A single extraction does not remove all the sugar from the slices, but the greater part is removed where the slices are sufficiently

thin, and the quantity of sirup that may be obtained from a second extraction is not sufficient to warrant the time and labor involved in its extraction and subsequent evaporation.

HEATING THE EXTRACT.

The extracted juice, or a similar extract prepared in any other manner, is heated under pressure in a container which may be sealed and is provided with a controlled valve for blowing off steam, a thermometer, and a pressure gauge. Pressure cookers, such as are used in many homes in the canning of vegetables, etc., have been found very satisfactory for this purpose; an illustration of one type of pressure cooker may be found on the title-page of this bulletin.

The cover having been fastened down, the extract is heated to a temperature of 226° to 230° F. (108° to 110° C.)—corresponding to a pressure of approximately 21 pounds to the square inch—and maintained at this temperature for an hour, blowing off a considerable quantity of steam at approximately 15-minute intervals. When heat is first applied, the valve is left open, to permit the escape of air, and it is closed as soon as steam begins to appear. At the end of the heating the steam is permitted to blow off rapidly, and the extract, which should be of a pale yellow color and entirely clear, is strained through cheesecloth or muslin, to remove the slight quantity of coagulated material, and is then ready to be evaporated to sirup. Ordinarily this treatment removes the objectionable "beety" odor and flavor from the extract and consequently from the sirup. This process is recommended, though the time and temperature are not necessarily confined to those mentioned; thus, very successful results have been obtained by heating to 230° to 233° F. (110° to 112° C.) for one-half hour with the constant blowing off of a slight quantity of steam.

EVAPORATING TO SIRUP.

The extract is placed in a kettle made of tin, aluminum, or enamel ware and evaporated to sirup by boiling briskly. A shallow, flat pan is more satisfactory, as it permits the extract to be reduced to sirup in a shorter time through more rapid evaporation and results in a lighter colored sirup. For the reason stated in connection with the extraction, vessels of copper or iron should not be used for treating the extract or for evaporating it to sirup. The slight quantity of scum that collects on the surface during the evaporation should be constantly removed. Skimmers made especially for skimming sirup may be purchased, but a square piece of tin perforated with many fine holes, turned up to a height of about one-half inch along two of its edges and fastened to a wooden handle, will be found satisfactory. Great care must be taken toward the end of the evaporation to avoid burning or scorching the sirup.

If it is desired to do so, the heating of the extract under pressure may be omitted and the extract boiled directly to sirup. Sirup produced by this process will be palatable, but it will be inferior to sirup produced from pressure-heated extract, because it will retain to a greater or less extent an unpleasant flavor and taste which are eliminated by heating. Further, it will usually be cloudy or opaque to a greater extent, and it may be darker in color.

In connection with the production of other sirup, such as sorghum sirup and cane sirup, the juice is sometimes clarified by adding lime or other chemicals or by treatment with infusorial earth. Such processes are not satisfactory when the sirup is produced upon a small scale, and it is strongly recommended that no attempts be made to use them in the production of beet sirup upon a small scale, as they will result in sirup of an extremely inferior quality. Such processes can be applied satisfactorily only where the sirup is produced upon a large scale and under chemical control.

The sirup may be evaporated to any thickness desired, but a sirup containing 70 per cent total solids is suggested as suitable for table use. As a liquid thickens, the boiling point is raised; a thermometer, therefore, affords a satisfactory means of determining when the sirup has reached a density of 70 per cent solids. Water at ordinary pressure or at sea level boils at 212° F. (100° C.). In testing a sirup for its density in this manner, it is advisable to test the accuracy of the thermometer by placing it in boiling water and noting the boiling point registered. The sirup is then evaporated until the thermometer registers 12 degrees higher than this point (in the case of the centigrade thermometer 6.5 degrees higher). Altitude affects the boiling point of liquids. For every 500 feet above sea level, roughly speaking, the boiling point is lowered 1° F., so that water at a point 2,000 feet above sea level would boil at 208° F. and a finished sirup at 220° F. In taking the temperature one must be careful not to permit the bulb of the thermometer to touch the bottom or sides of the evaporating vessel or to be exposed above the surface of the sirup; otherwise, an incorrect reading will be obtained.

STORING THE SIRUP.

The sirup should be stored in bottles, jars, or cans that have been cleaned and then thoroughly sterilized with boiling water or with steam. The sirup should be placed in the containers while boiling hot and the containers sealed at once in an air-tight manner. Otherwise, the sirup may possibly become inoculated with the micro-organisms that produce fermentation and molding, and "souring" or molding may take place.

YIELD OF SIRUP.

The yield of sirup obtained from the slices from 100 pounds of beets varies from 5 to 8 pints. The quantity of débris—crowns, green portion, and peel—varies from 40 to 50 per cent, and consequently the quantity of slices from 100 pounds varies from 50 to 60 pounds. The variation in the yield of sirup depends upon the variation in the percentage of sugar in the beets, which ordinarily runs from 12 to 20 per cent, also upon the quantity of débris, and the losses in handling the extracts and in skimming the sirup.

CHARACTER OF THE SIRUP.

Sirups made at different times by the process here described were of a light to dark-amber color and were free from the unpleasant odor and flavor which have frequently been found in sirups produced by direct evaporation of the extract, without the preliminary heating under pressure, and which have usually been found in sirups made from untrimmed and unpeeled beets. Many of the sirups were clear, others somewhat cloudy, the average cloudiness being no greater than in average cane or sorghum sirup. Sirups such as cane, sorghum, and maple, possess characteristic flavors, and the aftertaste of any one of them may be disagreeable to a person who is accustomed to any other. Beet sirup has a flavor quite distinct from any other sirup, the first taste being agreeable and very sweet, while the aftertaste is faintly similar to that of hoarhound, and expressions of opinions from numerous persons indicate that, as in the case of other sirups, it is agreeable to some people and not agreeable to others.

The average of the total solids in a number of sirups boiled to 223.7° F. (106.5° C.) was 70.29 per cent. The average percentage of suerose was 63.20 and of invert sugar 2.73; or, combining the two, the average percentage of total sugar in the sirup was 65.93. Sucrose is the same as the ordinary granulated sugar sold in grocery stores. Invert sugar, which is produced from sucrose through certain changes that take place, differs in its ehemical characteristics from suerose but possesses practically equal food value.

Beet sirup is very likely to crystallize or "sugar out," especially when stored in a cold placee, the erystals of sugar usually being large and having the appearance of rock-candy crystals. The sirupy part may be drained off and used in the ordinary manner, while the sugar may be used for sweetening. Care should be taken when using it, because it dissolves more slowly than ordinary granulated sugar. In the case of a sirup containing sucrose and invert sugar, the tendency to erystallize decreases as the proportion of invert sugar inreases,

and when the correct proportion of invert sugar and sucrose has been obtained the sirup will not crystallize. At present, processes for controlling the proportions of invert sugar and sucrose are entirely unsuitable for use in the home or on a small scale, as, when used, they necessitate careful use of special reagents.

USES OF BEET SIRUP.

The principal use of beet sirup is as a table sirup, but it may be used for all purposes for which other sirups are used, as in making candy and in making dark-colored cake and sweet bread. It may also be used in place of part of the sugar used in making jams. A pint of beet sirup containing 70 per cent of total solids will contain very nearly $14\frac{1}{2}$ ounces of sugar, and thus, when substituting sirup for sugar, it will be necessary to add slightly more than 1 pint for each pound of sugar. A pint of sirup will also contain almost one-half pint of water, and when it is used in making cake or bread less water than usual should be added. When it is used in making jams, longer boiling will be necessary, in order to evaporate this added water.

The process as here described is intended primarily for the production of beet sirup on a small scale, as in the home. It is not improbable, however, that at some time beet sirup may be produced profitably on a factory scale—utilizing the by-products as cattle-feeding material—especially in certain sections of the West admirably suited for the production of beets, but situated far from a beet-sugar factory and where the available agricultural land is insufficient to support a sugar factory.